MANAGING TRAFFIC CONGESTION IN SMALL SIZED RURAL TOWNS IN SOUTH AFRICA: THE CASE OF VHEMBE DISTRICT MUNICIPALITY

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ABSTRACT

This paper presents results and findings of the traffic congestion study conducted in Vhembe District. The purpose of the traffic congestion study was to assess and profile the existing traffic congestion landscape in the District with a view to identifying high, medium and low congestion areas in the Municipality. The results provide a portrait of congestion complete with a description of required infrastructure and services, which implemented will contribute significantly to a reduction in congestion. The findings highlight the major traffic congestion areas including presenting a platform of measures and actions that the Municipality can adopt in tackling congestion issues differently in the study area.

Key Words
Traffic, congestion, safety, accidents, interventions, Vhembe District Municipality

1.0 INTRODUCTION

Better management of traffic congestion through inter-alia strategic provision of accessible and affordable rural transport is essential in improving quality of life for rural communities. Traffic congestion is a condition that occurs as the use of roads increases - characterised by slower speeds, longer trip times, and increased queuing (Kerner, 2004; Chakwizira, 2007). Streets and roads tend to be congested in places that are attractive to people and that enjoy economic prosperity. The root cause of the problem is that too many people want to move at the same times each day. The efficient operation of both the economy and the school systems requires that people work, go to school, and even run errands during the same hours so that they can interact with each other (Adams et al., 2003). As a result, we may always need to live with some degree of congestion, particularly in the urban areas. Excessive traffic congestion has significant costs, such as lost time, driver stress, vehicle costs, accidents and elevated pollution (Kerner, 2009; VDM, 2013).Mobility, free traffic flow and access to transport facilities is essential to the everyday life of the rural communities in order to break their isolation and become active participants in developing their lives, hence the need to fight traffic congestion and its associated ills.

The Moving South Africa (MSA, 1996) strategy predicted that, unless the current growth in traffic situation is somehow arrested, the vehicle population in South Africa would have increased by a staggering 64% in 2020 (NDoT, 2009).The greater the number of vehicles on the roads, the greater the volume of traffic congestion. Research evidence exists that strongly suggest that more roads attract more vehicles (Adams et al., 2003; Duranton, 2011). Congestion can also occur due to non-recurring highway incidents, such as a road crash or roadworks blockage or diversion, which may reduce the road's capacity below normal levels.

Several basic types of strategies may be combined to reduce traffic congestion. The previous practice relied primarily on adding road capacity to address traffic congestion (Adams et al., 2003). There is increasing evidence that few regions will ever be able to afford construction of sufficient road lanes to solve the peak hour congestion problem (Sloman et al., 2010; Chakwizira et al., 2011). Adding capacity to other transport systems can relieve some of the pressure on badly congested roads, while widening transport choices (VDM, 2013). Another major category of strategies is focused on increasing the efficiency of the existing system. For example, improved traffic signalization or incident management can reduce delays (Sloman, 2010).

1.1 Aim of paper

This paper presents the results of a traffic congestion study in VDM. The implications of the congestion study for policy making and project development is also elaborated. The analysis is conducted taking into account the existing traffic network's design capacity and ability to adapt and respond to traffic congestion at pressure points in the study area.

1.2 Purpose of paper

The main purpose of the study is to share the findings of the traffic congestion study in VDM. The ensuring discussion will assist in the formulation of a traffic congestion strategy that leads to the provision of adequate transport infrastructure and services in the study area. Overall, the objectives of the traffic congestion study included the need to propose measures to improve economic productivity in the study area; reduce delays, improve traffic flow and improve travel times; reduce traffic congestion areas; reduce accidents; and prevent congestion from reaching uncontrollable levels.

2.0 RESEARCH METHODOLOGY

2.1 Study scope

The scope of work covers the four local municipalities within the jurisdiction of the VDM. The four local municipalities are: Makhado; Thulamela; Mutale and Musina.For the purpose of this study, the key economic areas and heavy traffic generators in the VDM are Thohoyandou, Makhado, Musina andMutale. Of the four towns, Thulamela and Makhado are considered to experience more congestion. This is based on review of periodic traffic counts by the District department of transport. Mutale is considered the least congested. Thus the traffic counting surveys focused most intensely on Thulamela and Makhado. Some points had been selected in the Musina and Mutale areas. These points were typically major intersections as well as axial roads entering and exiting the urban areas.

2.2 Study Area

The VDM comprises of urban, semi-rural and rural systems, i.e. Musina, Louis Trichardt and Thohoyandou (urban), Mutale, Vuwani, Masisi, Dzadzani and Waterval/ Elim (semi-rural) and the hinterlands and hamlets (rural areas).

2.3 Study Methods

The study involved analysis of both primary and secondary data sources. In addition, interviews with relevant stakeholders, particularly the VDM officials were undertaken. Primary data collection took the form of fieldwork surveys, including key informant interviews (KII). Local fieldworkers were recruited and trained in terms of questionnaire administration and interpretation of the survey form. Manual traffic volume studies were conducted at selected road intersection points making use of purposive sampling. These focused on both turning movement counts as well as cordon counts. The selected cordon traffic counting points were mainly on the entrances and/or exit points of Makhado, Musina, Mutale, Thohoyandou and Malamulele towns while the turning movement counts focused on known busy CBD intersection portions of the respective towns. Consequently, the CBD, known busy intersections as well as axial entry and exits routes were selected traffic counting points. The Traffic counts were employed to determine the number & volume, movement and classification of congestion levels at selected locations. The adopted methodology was developed to allow capturing of all vehicular movements in the study area.

3.0 LITERATURE REVIEW

3.1 Linkage between sustainable land use, transportation planning and congestion

The configuration and relationship between rural land use, transport networks and transport operations have profound implications for congestion. Typically, rural transport needs include farm-to-market or mine-to-plant connections and the intermittent challenges associated with rural service delivery. Route corridors that connect rural areas to markets or mining enclaves and or tourism destinations are typically clogged periodically, seasonally or temporarily. Understanding the nature of land use, incentives for travelling and managing such dynamics intelligently can mean periodic, seasonal or temporary congestion or not. It is therefore essential to realize that the meaning of traffic congestion and response to it may differ when one adopts rural lenses as compared to urban lenses. Whereas, congestion in urban areas may be associated with road rage in rural areas it may be associated with tolerance, marvel as well as appreciation when a large herd of elephants may be crossing leisurely a route in the rural network.

Long distances between rural population centres and areas of economic activity (such as farms, mines, or plants) have been associated with localized traffic congestion. This is exacerbated by a tradition of local self-sufficiency combined with extended travel for special household and business purposes. Overall, rural transportation patterns and needs are associated with placing traffic flow and movement pressure on economic nodes such as rural agricultural hubs, rural industrial hubs, rural commercial hubs as well rural mining and shopping centre hubs.

3.2 Theories explaining causes of congestion

A number of theories exist that seek to explain and simplify the causes of traffic congestion. The mainstream classical theories were developed in response to motorization and urbanization challenges in the World. They are applicable in rural areas, although adjustments to suit rural contexts may be required. These are reviewed in table 1.

Table 1: Classical traffic congestion theories

Mathematical theories	Economic theories
• Traffic flow studies origins date back to the 1930's with the application of probability theory to the description of road traffic and pioneering volume and speed modeling studies. This period also witnessed the investigation of performance of traffic at intersections. • Since 1950's shifts in traffic flow theories saw the incorporation of a variety of approaches, such as car-following, traffic wave theory (hydrodynamic analogy) and queuing theory. • Consequently, congestion traffic simulations and real-time observations have revealed that in heavy but free flowing traffic, jams can arise spontaneously, sometimes triggered by minor events ("butterfly effects"), such as an abrupt steering maneuver by a single motorist. • In addition, traffic flow is often affected by signals or other events at junctions that periodically affect the smooth flow of traffic. • Boris Kerner's three-phase traffic theory, indicates that vehicular traffic can be either free or congested. In addition, traffic occurs in time and space, i.e., it is a spatiotemporal process. • Traffic congestion can be reconstructed in space and time based on Boris Kerner's three-phase traffic theory with the use of the ASDA and FOTO models introduced by Kerner.	• Congested roads can be viewed as one example of the application of the tragedy of the commons theory. • This is precisely because in most places road space is a free public good. • Treating roads as a public good promotes their over use by drivers since there are no financial disincentives for drivers not to over-use them. • Consequently drivers use them up to the point where traffic collapses into a jam and congestion creeps in. • Logically, road pricing has been proposed as one measure that may reduce congestion through economic incentives and disincentives. Economist Anthony Downs argues that rush hour traffic congestion is inevitable because of the benefits of having a relatively standard work day. • In a capitalist economy, goods can be allocated either by pricing (ability to pay) or by queueing (first-come first-served); congestion is an example of the latter. • Instead of the traditional solution of making the "pipe" large enough to accommodate the total demand for peak-hour vehicle travel (a supply-side solution), either by widening roadways or increasing "flow pressure" via automated highway systems can be employed. • Downs advocates greater use of road pricing to reduce congestion (a demand-side solution, effectively rationing demand), in turn plowing the revenues generated there from into public transportation projects.

Source: adopted after Kerner, 2009

Given table 1, classical congestion theories are an indispensable construct for traffic flow models and tools that are being used in the design and operation of streets and highways especially with regard to treatment of congestion spots and management.

3.2.1 Typical causes of congestion in rural areas

In rural areas congestions is caused by a number of factors. Table 2 presents the classical factors with application to rural areas.

Table 2: Causes of rural congestion and implications

Causes of Congestion	Explanation
Bottlenecks	Points where the roadway narrows or where regular traffic demands cause traffic to backup due to a lack of needed capacity e.g. based by number of lanes to carry traffic, curvature of highway/road, condition of road [tarred, gravel & maintained or not], side clearance of verges, nature interchange and intersection design, potholes & road gradient
Traffic Incidents	Crashes, stalled vehicles, and debris or rock falls on the road e.g. broken down vehicles, trucks and buses on the roads, animals such as donkeys crossing or jaywalking on the roads, slow moving vehicles such as tractors on the roads/highways etc.
Work zones	New road building and maintenance activities like filling/patching potholes
Bad Weather	This cannot be controlled but travellers can be notified of the potential for increased congestion, e.g. mist & heavy downpours of rain.
Poor Traffic Signal timing	Faulty operation of traffic signals or green/red lights where the time allocation for a road does not match the volume on that road are the cause of congestion on major and minor streets
Special Events	Cause spikes in traffic volumes and changes in traffic patterns and either cause delay on days, times or locations where there usually is none, or add to regular congestion problems e.g. ZCC Annual Religious Retreats/Festivals
Transport governance	Lack of capacity and mechanism to effectively manage use of road/highway capacity
Inappropriate congestion solutions	When searching for a solution, most people immediately think of adding a new lane to an already overburdened /road highway
Types of Congestion in Rural areas	
• Seasonal congestion can also have an impact on tourist and holiday traffic • Traffic congestion can affect goods movement along congested corridors e.g. R524 in Vhembe District • Although more sporadic, delay occurs in rural areas and heavily travelled inter-city corridors • Particularly hit are the arteries around popular tourist destinations such as Mapungubwe & Kruger National Park • Congestion in part is due to heavy freight traffic	

3.4 Measuring congestion

Traffic congestion occurs when a volume of traffic or modal split generates demand for space greater than the available road capacity; this point is commonly termed saturation (Kerner, 2009). Traffic congestion is a condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicular queuing. The most common example is the physical use of roads by vehicles. When traffic demand is high enough such that vehicles slow down speeds this leads to congestion. As demand approaches the capacity of a road (or of the intersections along the road), extreme traffic congestion sets in. Table 3 presents the roads and highways level of service standards applicable to both urban and rural areas.

Table 3: Roads and highways level of service

Level of Service	Description
A	Free flow with low volumes and high speeds.
B	Reasonably free flow, but speeds beginning to be restricted by traffic conditions.
C	In stable flow zone, but most drivers are restricted in the freedom to select their own speeds.
D	Approaching unstable flow; drivers have little freedom to select their own speeds.
E	Unstable flow; may be short stoppages
F	Unacceptable congestion; stop-and-go; forced flow.

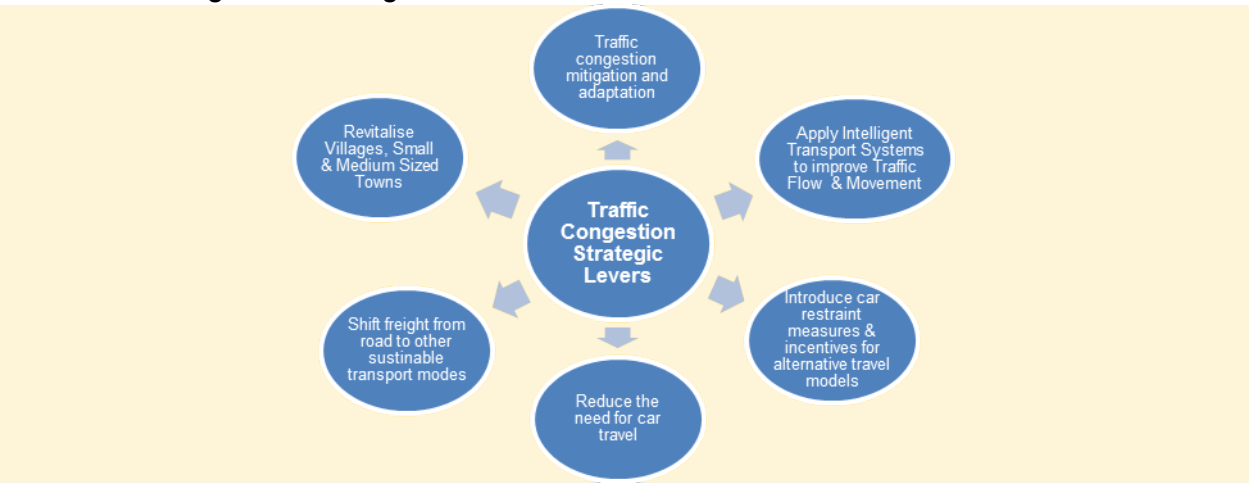
Source: Adapted from the AASHTO Green Book. 1995 Highway Capacity Manual (Special Report 209), Transportation Research Board, Washington, DC, Third Edition, updated 1994

Congestion can be measured in various ways, including roadway level of service, average traffic speed, and average congestion delay compared with free-flowing traffic. The capacity of a road depends on various design factors such as lane widths and intersection configurations. Traffic speed and flow on urban streets are determined primarily by intersection capacity, which is affected by traffic volumes on cross streets and left turn signal phases. A vehicle's road space requirements increase with speed, because drivers must leave a safe distance between their vehicle and other objects on or beside the roadway.

3.5 Traffic congestion strategic levers and options

Figure 1 presents the traffic safety audit strategic levers and options for better management of small/medium sized rural town congestion challenges.

Figure 1: traffic congestion strategic levers



In short, figure 1 points out that in order to craft and generate sustainable traffic congestion strategic levers, the focus should be on an integrated set of solutions that considers *inter alia* the following, namely:

- The full recognition that the existing road network can be managed better beyond the option of expanding or constructing new roads. It is acknowledged that car use is essential to many people living in both urban and rural areas but perhaps our primary focus should be to aim to reduce the need to travel by car, prioritise sustainable travel choices and promote more efficient use of cars, particularly higher occupancy levels that what we are currently achieving.
- There is merit in viewing demand for road-based transport as one area in which travelling can be reduced where possible. Indeed a range of measures is needed and are available to manage traffic levels, reduce car dependency and improve sustainable travel options. Room exists to implement a suite of a combination of better planning and infrastructure, promotion and rebalancing of travel costs in structuring both the built and natural environments.
- In addition, there is need to embark, retain and reopen local facilities in villages and smaller market towns to ensure the vibrancy of rural and semi-rural communities and to reduce the need to travel to larger centres as part and parcel of seeking complete solutions for traffic safety challenges in both urban and rural areas.

4.0 DISCUSSION OF STUDY RESULTS AND FINDINGS

Regarding public transport services, rural incomes are generally too low to allow widespread ownership of private transport. When incomes are low, people will not use public transport services if they can walk. Only in an emergency will a motor vehicle be used. Furthermore, low incomes make people unwilling to travel. Most rural people are thus dependent on buses and taxis for their day-to-day travelling needs.

4.1 Characteristics of Studied Intersections

The studied intersections are comprised of 4-legged and 3-legged road junctions selected from different locations along major axial routes in the study towns. The intersections serve as links to major routes which connect different types of land use activities in the study area. The majority of the intersections are unsignalised with traffic flow during the peak periods being controlled at times by traffic policeman. A common feature for some of these intersections is the presence of road side hawkers and traders and the location of retail and industrial outlets along the intersecting roads. These add to obstructions and parking problems from customers who patronize the sold products and thereby impeding the free movement of vehicles. Table 1 shows the characteristics of studied intersections in Makhado & Thohoyandou. A similar approach was utilized in Musina, Elim, Mutale and Malamulele town.

Table 1: Intersection Characteristics and Associated Land Use

No.	Intersection name	Intersection Type	Intersection Treatment	Land use characteristics
Makhado Town				
1	N1/Stubbs, Baobab	4-legged	Roundabout	Caltex Garage, OK Grocer Shopping Centre, Low Density (New Town), Open Spaces
2	N1/R524/Songwozi	4 -legged	Four Way Stop	Makhado crossing shopping mall, Makhado Recreational Park, Tourism centre, Residential - New Town, Open Space
3	N1/Main/Rissick Street [R522]	4-legged	Four Way Stop	Caltex Garage , Market, Car Servicing, Car Dealer, Open Space
4	N1/Elim /R578	3 legged	Stop sign from Elim & Give way from Polokwane	Farms, Farm Store, CVO & Emmanuel School, Butchery
Thohoyandou				
1	R524 /Malamulele/Makhado/Sibasa/Bogon Villa	4 legged	Roundabout	Service Stations, Thohoyandou Stadium, Residential, Commercial
3	University, Mphephu, Sibasa	4 legged	4 legged signalized intersection	Venda Plaza, Shoprite, Clothing & Furniture, Residential, Open Space, Khoroni Hotel, Informal Trading

4.2 Traffic generators in the VDM

Traffic can be generated by various factors. The most common causes of traffic congestion in the Vhembe District Municipality are: economic and attractive nodes; traffic incidents and slow moving vehicles; stray animals and lack of facilities. The major economic areas and heavy traffic generators in the VDM are presented in table 2.

Table 2: Economic and attractive nodes in the study area that attract congestion

Urban Nodes	Tourist & Social Facility Areas	Comment
Thohoyandou; Makhado; Musina; Mutale; Malamulele and Elim	BenLavin Nature Reserve; Dzata Museum; Dzundzwini View Point; Honnett Game Reserve; J.J.Coetser Memorial Plaque - Camp Site; Masekwaspoort Pass; Matshakatini Nature Reserve; Membe Gate; Musina Nature Reserve; Nwanedi Game Reserve; Phiphidi Waterfall; Rivoni Society For the Blind; Schoemansdal Museum; The Treasure Chest; The Big Tree; Thohoyandou Stadium; and Wyllie's Poort Pass	Thulamela and Makhado are assumed and known to be the most congested because of their economic stature whereas Mutale is the least congested. Some of the most common areas in the study area that tend to attract and/or generate more traffic include a number of tourist and games reserves.

4.3 Purpose of travelling in Vhembe District Municipality

According to the VDM Integrated Transport Plan (ITP), the highest percentage of travelling peoplei.e. 33.8%, do so for educational purposes. This is followed by 22.1% of travelling people who are local visitors/international tourists. The work trips in VDM are almost 3 times (at 9.5%) the size experienced in Limpopo province (at 3.4%). This reveals a vibrant district municipality. Table 3 below shows a percentage of people who make a trip for different purposes. The same goes with educational trips. The same patterns occurs for visitors, shopping trips, sporting trips as well as Church engagements. This has implications for localised congestions in Vhembe with peak and seasonal implications that work, educational, tourism, shopping and church trips experience congestions in the study area.

Table 3: Percentages of People Who Make Trips For Different Purposes

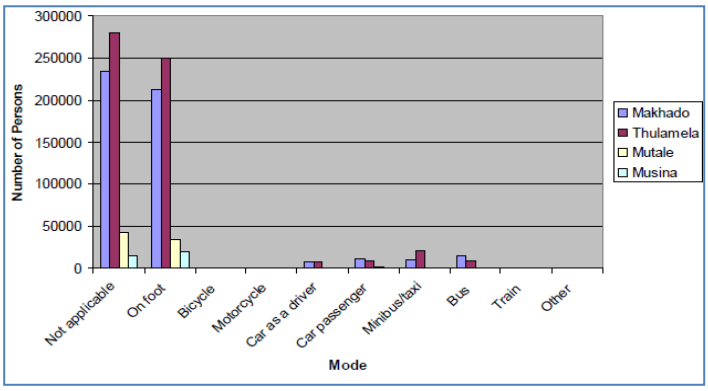
Trip Purpose	% Trips In Terms of VDM	% Trips In Terms of the Total Limpopo Province
Work	9.5	3.4
Education	33.8	12.1
Shop	10.9	3.9
Looking for Work	1.4	0.5
Medical	1.7	0.6
Welfare	0.3	0.1
Visit	22.6	8.1
Sport	13.1	4.7
Church	2.5	0.9
Other	9.5	1 .5

Source: Vhembe ITP quoted in VDM, 2013

4.4 Modes of travelling

The National Household Survey, 2003 conducted by the Department of Transport revealed that only 23% of the households in the VDM have access to at least one car (VDM, 2013). The mean number of cars per household is 0.3. Therefore, at least the remaining 77% of the households depend on public transport to run their errands. There are no commuter trains in the VDM, which normally carry a large volume of passengers. Therefore the most available public transport modes are buses, minibus taxis and light delivery vehicles (LDVs) in other areas. These existing transport arrangements are not properly aligned to contribute towards the reduction and minimisation of congestion in the study area. Figure 1 below shows the travelling modes in the VDM.

Figure 2: Mode of Travel Per Local Municipality in the VDM



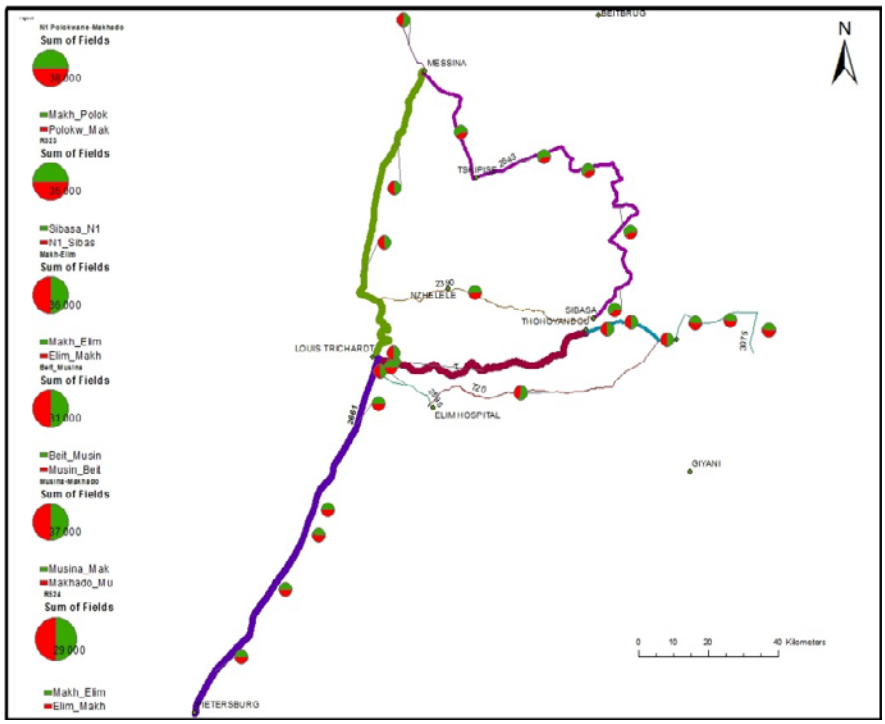
From the information depicted in Figure 2 above, it is clear that most travelling, irrespective of the mode of transport, is done in both Makhado and Thulamela towns. This is also emphasized by public transport surveys conducted during the development of the VDM ITP. The study revealed that there are more public transport routes in the Makhado and Thulamela municipalities than there are in Musina and Mutale. The not applicable category relates to respondents who are home bound. The category indicates that most rural people do not travel outside their immediate neighbourhood.

4.5 Pattern of Traffic Flow

Table 4 shows the average traffic volumes in vehicles per hour at some of the studied junctions for both morning and evening peak. The table presents findings from Makhado and Thohoyandou. The N1/Stubbs, Baobab & N1/Elim /R578 are major intersections which are incidentally feed by traffic from surrounding rural villages and high density suburbs such as Madombinja, Kutama, Elim Villages (Mashau, Bungeni etc). It is therefore little wonder why the Elim intersection was prioritised to convert it from a two way stop into a standard roundabout. Construction works on this spot improvement solutions is at an advanced stage of completion and expected to be finalised before December 2014.

Table 4: Average Volume of Traffic at selected junctions in Makhado & Thohoyandou

Intersection Identity	Morning Peak		Afternoon Peak	
	VPH (6-9am)	% of Total	VPH (4-6pm)	% of Total
Makhado				
N1/Stubbs, Baobab	295	22.2	928	38.6
N1/R524/Songwozi	328	24.7	428	17.8
N1/Main/Rissick Street [R522]	353	26.6	473	19.6
N1/Elim /R578	348	26.2	574	23.8
Total	1324	100	2403	100
Thohoyandou				
R524 /Malamulele/Makhado/Sibasa/Bogon Villa	486	59.3	771	64.3
University, Mphephu, Sibasa	333	40.7	428	35.7
Total	819	100	1199	100



Map 1 presents traffic flow in the study area. It indicates that high volume of traffic is experienced on the N1 that traverses the District. These points are namely from Polokwane - Louis Trichardt – Musina –Beitbridge. Regional economic hubs that also experience high traffic flow volumes include R523 (Thohoyandou-Musina), R578 (Elim-Louis Trichardt), R 101 (Polokwane to Musina) & R523 (Sibasa to N1).

Map 1: Traffic Flow Patterns in Vhembe District

4.6 Pattern of Traffic delays

Table 5 shows the average delay times in minutes at the studied intersections for both morning and afternoon peak periods. The average traffic delay is yet to reach peak typical urban congestion levels. However, a ball feel of intersection areas that have potential for congestion especially during weekends, month ends and peak holiday periods is gleaned. In addition, motorists exercise flexibility regarding evening travel rather than during morning peak as they rush to get to work and school in time. While N1/Stubbs, Baobab carries heavy traffic flow, delay is minimum compared to the N1/Elim /R578 intersection. This is because currently the is a four way stop sign intersection N1/Stubbs, Baobab while the N1/Elim /R578 is a two way stop sign which negatively affects the Elim leg as long queues build up for right turn movements. This is expected to be a thing of the past once the construction of the roundabout expected to be complete by December 2014 is effected. N1 Songwozi and N1/Rissick experience heavy delays bas these routes connect Louis Trichardt town with the major regional corridors such as R524 and R522. In the long term, exploring the erection of signalised intersections as well as the construction of flyovers complete with off-ramps is not far-fetched options. In the medium term, exploring the advisability of constructing ring roads that allow through traffic (i.e. especially freight transport with no business in the town) to by-pass the town is another option. This may prove difficult given that Louis Trichardt has limited land availability.

Table 5: Average Traffic delay at selected junctions in Makhado & Thohoyandou

	Delay time in Minutes			
Intersection	Morning Peak		Afternoon Peak	
	minutes	% of Total	minutes	% of Total
Makhado				
N1/Stubbs, Baobab	12	17	8	17
N1/R524/Songwozi	18	26	13	27
N1/Main/Rissick Street [R522]	22	31	16	33
N1/Elim /R578	18	25	11	23
Total	70	100	48	100
Thohoyandou				
R524 /Malamulele/Makhado/Sibasa/Bogon Villa	32	66	22	69
University, Mphephu, Sibasa	16	34	10	31
Total	48	100	32	100

In order to address traffic congestion delays in Thohoyandou, police officers direct traffic on the University of Venda/Khoroni hotel intersection during the morning and afternoon peak. This is irrespective of whether the traffic lights are functioning or not.

4.7 Profiling traffic congestion causes and dimensions in VDM

A number of factors explain the existence of traffic congestion in VDM and these are discussed in details in table 6 that follow.

Table 6: Profiling traffic congestion causes, dimensions & implications in VDM

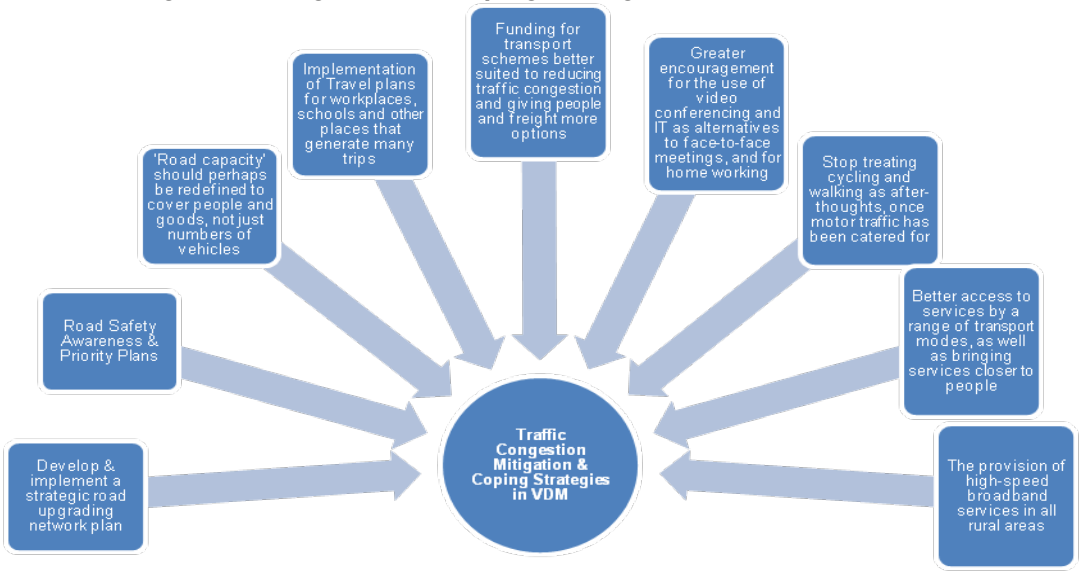
Identified Cause	Description	Examples	Congestion Implications
Traffic incidents and slow moving vehicles	Disabled vehicles and accidents scenes increase congestion and compromise road safety. Although random events, they tend to cause great delays where traffic volumes approach road capacity. In uncongested conditions an incident causes little or no traffic delay, but a slow heavy vehicles or car on the shoulder of a congested road can increase delays on the adjacent lanes. Heavy vehicles tend to require more road space and are slower to accelerate, and so contribute to more traffic congestion than light vehicles.	Common on the following roads: N1 between Makhado to Musina; R524 between Makhado and Thohoyandou; R81 between Malamulele and Giyani; and R523 between Nzhelele and Thohoyandou. Figure 5 (extreme left and centre) below shows the broken down vehicles along the N1 road between Makhado and Musina. Figure 5 (extreme right) shows a slow moving vehicle in Elim. **figure 5: Broken & Slow moving Vehicles in Study Area**    Broken down vehicles along the N1 road | Slow Moving Vehicle in Elim	Slow moving vehicles also increase traffic congestion, especially in town. The VDM has many farms and therefore there are a number of slow moving vehicles in ***tows*** that are near the farms. Makhado and Elim are some of the affected towns. There is need to encourage such farmers to provide parallel/side roads on their farms/alternatively construct slow lanes/widen road shoulders in affected road sections.
Stray animals along the roads	Stray animals along the roads can be a danger to traffic. When such animals cross the roads, motorists have to wait for them and that causes congestion. Moreover they can cause accidents, which then lead to delays, vehicle queuing and congestion. The VDM is affected by stray animals mainly because of its rural nature. Stray animals are common on many roads throughout the district municipality.	Figures 6 to 8 show the stray animals on the VDM roads. The affected roads include but not limited to the following: D4 between Elim and Vuwani; R523 near Nzhelele; D3671 near Mutale and N1 between Makhado and Musina. **figures 6 to 8: showing stray animals on the VDM roads.**    Figure 6: Cattle Blocking the Road on D3671 Near Mutale | Figure 7: A Donkey Crossing the Road on R523 Near Nzhelele | Figure 8: Cattle Crossing the Road on D4 Between Elim and Vuwani	Consider measures for controlling animal movement such as erecting fences along major rural road corridors and strict enforcement of penalties for farmers and rural dwellers who allow their animals to stray beyond their control.
Inadequate public transport & parking facilities	The lack of public transport infrastructure and facilities also impacts negatively on traffic congestion management. Four different types of facilities could be identified, namely: Stops or lay-byes; Ranks; Terminals and Holding areas. Informal and small taxi ranks make it hard to manage taxi movements and parking. As a result some taxis park on the road or take time to get a parking space on the demarcated area. Such taxis close the roads and increase congestion.	Although there is a public transport facility at Beit Bridge, it is too small to handle the number of taxis operating in that area. As a result some taxis end up parking on the road or struggle to get into the facility as indicated in Figure 9& 10. This impacts negatively on congestion. This is a situation at places like Elim as indicated in Figure 9 & 10 below. **Figure 9 & 10: inadequate taxi ranking facilities**   Figure 9: Taxis Blocking the Road at Elim | Figure 10: Inadequate Ranking Facility at Beit Bridge	Traffic congestion in the VDM is also caused by the lack of public transport facilities. Improving and upgrading public transport in a holistic manner can go a long way in addressing potential congestion triggers from the sector. Fast tracking the construction of Musina multi-modal transport facility/hub is one way of easing congestion in the border town. Congestion is particularly high during holidays, weekends and month-ends. Multi-governance integrating and synchronising cross border congestion reduction measures is essential.
Non-motorised transport	Traffic impacts on non-motorized transport, i.e. cyclists and pedestrians are usually ignored, although in typically	In towns such as Malamulele and Elim where there are inadequate non-motorised facilities such as the pedestrian walkways, the pedestrians walk on the road and this affects traffic. Figure 11 below shows the pedestrians walking	Ignoring the impacts on non-motorised travel tends to understate the benefits of Travel

facilities	predominantly rural areas such as VDM they represent a major share of travel delay.	on the road in Malamulele whereas Figure 12 shows a cyclist in the road at Makhado respectively. **Figure 11 & 12: lack of pedestrian friendly infrastructure**  Figure 11: There are No Pedestrian Walkways in Malamulele  Figure 12: Cycling on the Road in Makhado	Demand Management(TDM) strategies that reduce vehicle traffic volumes, and overstate the benefits of roadway capacity expansion that create barriers to non-motorised travel. Construction and provision of NMT infrastructure for pedestrians, cyclists and other NMT users is essential to reduce conflict and potential delay from NMT users, pedestrians and cyclists.
Inadequate Parking facilities	Another cause of traffic congestion in the VDM is the lack of parking facilities.	Towns such as Malamulele and Elim do not have adequate parking facilities. In Malamulele vehicles park behind each other and on the street (refer to figure 13 -15).  Figure 13: Vehicles Parked Behind Each Other in Malamulele  Figure 14: Vehicles Parked on the Street in Malamulele   Figure 15: Broken or Out-of-Order Parking Paypoints in Makhado	Provision of parking space, pricing road space as well as construction of parkades is some ways through which vehicles can be removed from the streets. This will have a positive impact in reducing congestion.
Traffic information and resting places	Motorists need to be informed as they travel. Knowledge of what is happening on the roads will enable traffic to flow smoothly. If a driver misses the turnoff, they have to make a u turn which may impact negatively on traffic. Clear information boards on the side of the roads will assist motorists with information and reduce driver stress.	Some of the information boards along the roads in the VDM have not been adequately maintained for some time. The information boards are aging, detaching from the columns they have been attached to or have already detached from the columns and are no longer visible to road users. On the other hand other boards are just too small to be noticed (refer to Figures 16-18). Figure 16 show the aging boards that need maintenance and/or rehabilitation on the R578 to Elim and D4 from Elim to Vuwani respectively. These boards are aging and some of the boards have already fallen or faded away. This is prevalent in places such as Beit Bridge as reflected in Figure 18. **Figure 16-18: aging and poorly maintained signs boards in study area**   Figure 16: Aging Boards on Near Elim that Need Maintenance  Figure 17: Fallen Board Near Beit Bridge   Figure 18: Small Information Boards	Without proper information motorists will be lost and add to congestion as they try to find their way round. In some instances the boards indicating that the roads have potholes are just too small to be noticed. Provision of incident management systems, boards and radio broadcasts on weather, accidents and events is essential in congestion management. This should be done making use of low cost and appropriate technology that is attuned to the capacity and resource endowments of small to medium sized rural town budgetary realities.

5.0 RECOMMENDATIONS

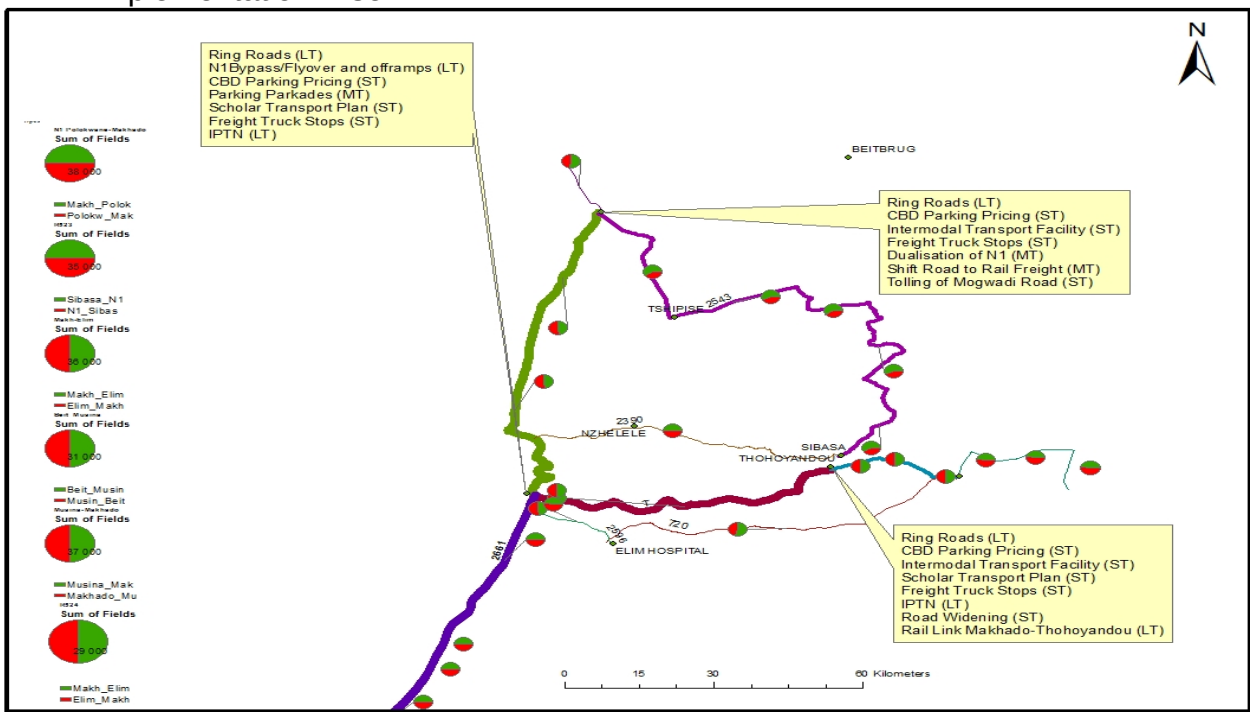
A list of *short term, medium term and long term* strategies that can be implemented to address traffic congestion in VDM was generated as an outcome of the traffic congestion study (VDM, 2013). The proposed projects relate much with public transport planning and management. They also deal with the updating of public transport infrastructure to increase feeder roads impact on the population's socio-economic welfare in the study area. In addition, it is recommended that the VDM should upgrade the rural road network to reduce accident inducing bottlenecks in that category of the road hierarchy. Equally important is granting road safety priority at schools with much emphasis on programmes involving the facilities, road safety education and enforcement. Figure 2 presents traffic congestion mitigation and coping strategies available for implementation in VDM.

figure 2: traffic congestion mitigation and coping strategies in VDM



As indicated in figure 2, travel plans for workplaces, schools and other places that generate many trips, such as tourist attractions should be developed for example. This has the advantage of drawing people away from private cars to using more efficient transport modes to meet work and school trip requirements. Better quality school bus services that go a long way in reducing school traffic is another options that can be pursued. It may also make sense to consider a radical initiative such as increasing parking charges at town shopping malls with the money raised used to improve non-car access, local delivery schemes and initiatives to revive failing shops in towns and villages. Some of the short term, medium term and long term strategies developed for managing traffic congestion in VDM are indicated in Map 2. Map 2 highlights of some proposed interventions at Musina, Thohoyandou & Louis Trichardt to address congestion in VDM. In summary the major interventions depicted in Map 2 include,

- ***Road pricing:*** This involves charging motorists directly for driving on a particular road. There are already two toll gates in the VDM, the Capricorn Plaza and the Baobab Plaza on the N1. The South African National Roads Agency Limited (SANRAL) is responsible for both toll gates. Road pricing applied on just one road may cause traffic to shift routes, increasing traffic congestion on other roads.
- An example of this is the shifting of traffic from the N1 toll route to R521 (Mogwadi Road) in the Capricorn District Municipality. More vehicles, especially heavy vehicles, avoid the toll gates on the N1 and use R521 to get to Beit Bridge. On the other hand road pricing can add to traffic congestion particularly during the holidays or when there are special events. Thus an event management programme is required to deal with such times. This is a long term measure, implementation wise.



Map 2 : Highlights of proposed interventions to address congestion in VDM

- ***Public transport improvements:*** This can be an effective congestion reduction strategy, particularly if implemented with other incentives to shift mode, such as parking pricing and road pricing. This is essential for the major commercial hubs in VDM, namely Louis Trichardt, Musina and Thohoyandou. Buses currently operate like taxis but there are not enough passengers to fill each bus. In the long term there is a need to redesign an integrated urban and rural public transport services in the VDM to address this problem.
- ***Improving and expanding rail network and services:*** This can play a major role in reducing traffic congestion since a large volume of people can be carried by one train for example. A single train can carry up to 2200 passengers which is approximately 34 buses or 147 minibus taxis. Although it is desirable to introduce commuter rail services in the VDM, the availability of land might be a problem but it is worth investigating in the long term whether the rail services cannot be introduced in heavily congested areas such as Thohoyandou and Makhado.
- ***Parking Management and Pricing:*** Parking management and parking pricing are the most effective ways to reduce car travel, and tend to be particularly effective in urban areas where congestion problems are greatest such as in Thohoyandou, Makhado & Musina. Driving and parking are virtually perfect complements: you need a parking space at virtually every destination. More efficient pricing of on-street parking would make urban driving more expensive but more efficient, due to lower levels of traffic congestion and the relative ease in finding a parking space near destinations, as well as providing new revenues. However, to justifiably apply stringent parking management and parking pricing policies, effective and efficient public transport system would be a prerequisite. In the short term, without reliable and safe public passenger transport in place, it would be extremely difficult to apply parking management and parking pricing policies as the appropriate mechanisms to combat traffic congestion.
- ***Freight Transport Management:*** Freight trucks represent a relatively small portion of total traffic but can make a relatively large contribution to congestion, due to their large size and slow acceleration. A large truck can contribute as much congestion as 3-6 passenger cars. The application of intelligent freight transport management in the short term in VDM can reduce total freight traffic and shift freight to less congested routes.
- ***Road Capacity Expansion***: Road widening is often advocated as ways to reduce traffic congestion. None of the towns in Vhembe district has by-passes or ring roads that can act as orbital channelling out traffic with no business in the towns of the district. However, it tends to be expensive, and may provide only modest congestion reduction benefits over the long run, since a significant portion of added capacity is often filled with induced peak period vehicle traffic. A large amount of additional capacity would be needed to reduce urban traffic congestion in the medium term in VDM.
- ***Intersection Improvements:*** *In the short term v*arious strategies that increase intersection capacity can reduce delays, since intersections are often a limiting factor in roadway traffic flow. These include additional lanes at the intersection approaches, left- and right-turn lanes, and improved signal synchronization. Gateways improvements in Thohoyandou, Makhado and Musina are an area for continuous attention.

6.0 CONCLUSION

This paper has provided a high level strategic assessment of the traffic congestion levers in VDM. The findings highlight the major traffic congestion generators as well as advance possible congestion coping and adaptation measures. Overall, the traffic congestion strategy should be treated as a living document that forms part of a district and local municipalities IDPs sector plans, SDFs & ITPs. It is therefore meant to be subjected to annual revision depending on the changes that need to be incorporated. The traffic congestion strategy essentially therefore advises the land use management system of the district municipality which need to be developed. The VDM public transport problems could therefore be solved by the improvement of the public transport system, i.e. both the public transport services (bus, train and taxi services), and related infrastructure. With a proper public transport system, congestion will be reduced in the VDM. All the proposed solutions should be used as a means to reduce road congestion. Lessons learnt for application in other South African rural towns include the following, namely:

- Rural road congestion is a reality and growing challenge for small to medium sized rural areas just as it is for the major metropolitan areas of South Africa.
- Solving rural road congestion is a complex and dynamic activity that requires innovative and creative solutions to the challenge. Expecting that the standard urban congestion toolbox is the magic is not enough. There is need to appreciate the rural towns complex and unique traffic congestion conditions. The thresholds for acting on congestion do not necessarily have to be identical as those for urban areas. The guiding principle has to be guided by the established norms, principles and values of the rural road system for the area concerned.
- Simple solutions such as introducing a filter or replacing a four way stop sign with a traffic roundabout or introducing four ways stops signs where none existed have great potential in addressing localized bottlenecks and relieving congestion on specific spots and road chainages of the rural transport network.
- While solutions such as road widening, ring roads construction, road tolling, or tolling of heavy occupancy vehicle lanes as well as use of intelligent information systems through vehicle to vehicle communication or a central command centre can also work in addressing congestion, it is not easy to implement these solutions in small sized rural towns. This is essentially so since such measures may not be tenable in the short term because of matters of local authority readiness, public acceptance as well as funding and transport agency capacity.
- Addressing road congestion requires a package of strategies. These should relate to transport demand management (TDM), transport supply management (TSM) & land use management.

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